N81-21953

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THE NATURE AND TREATMENT OF PROFESSIONAL ENGINEERING PROBLEMS: THE TECHNICAL WRITING TEACHER'S RESPONSIBILITY

Ben F. Barton, Professor
Department of Electrical and Computer Engineering
University of Michigan
Ann Arbor, Michigan 48109

and

Marthalee Barton, Lecturer
Department of Humanities
University of Michigan
Ann Arbor, Michigan 48109

INTRODUCTION

Rhetoric teachers often impute to engineering students a technical expertise in the treatment of problems addressed by professionals. This imputation has prompted two general pedagogical responses among technical communication instructors. The first response amounts to a denial of responsibility for assessing the professional caliber of a student's treatment of a technical problem. Technical issues are seen as the domain of the technical student, not of the rhetoric instructor. This particular version of territoriality is consistent with the historical emphasis in textbooks and pedagogical literature on mechanical, or formal, aspects of writing.[1] Moreover, these territorial bounds have not shifted greatly in recent years, even while pedagogical concern has broadened to encompass such issues as audience and purpose.[2]

The second pedagogical approach goes even further and turns a supposed defect--the rhetoric instructor's lack of technical expertise--into a virtue: The teacher and student interchange roles to allow an avid communication specialist to be instructed in the mysteries of the technical problem and its solution. Such deference to technical expertise has led to the suggestion that students "be asked to instruct the teacher."[3] Another call for role reversal is expressed thusly:

> "As teachers of technical writing, we cannot expect to be more knowledgeable in our students' subject area than they have a responsibility to be. Thus we can and should hold them responsible for actually educating us in their disciplines. The realization that they are expected to know more than the teacher who reads their work may be unnerving to some, but it may well be the most important education we can provide them."[4]

Such deference to student technical expertise is disturbing for two reasons. First, the belief that the student is more knowledgeable is valid only on one level--the level of subject matter, or of surface textualization of the technical materials. At a more meaningful level--the level of deep, or paradigmatic, structure--the student is often <u>not</u> an expert and the rhetoric instructor <u>can</u>, and <u>should</u>, be. Second, the undifferentiated belief in the student's technical expertise leads, in our view, to an unfortunate emphasis on the <u>tutorial</u> approach to problems. Such emphasis may address the needs of an overwhelmed rhetoric teacher but does not address the central problem of the student attempting to simulate professional performance. In fact, the crux of the student's problem is to distinguish the tutorial treatments of textbook problems, which dominate classroom experience, from the profoundly different professional treatments of problems typically addressed by engineers. A pedagogy based on reversal of educational roles thus reinforces the commitment to tutorial treatments of problems just when the student should be undertaking problems, and treatments, of a more professional ilk.

TUTORIAL VS. PROFESSIONAL PROBLEMS

What, then, are the differences between the textbook problems addressed by students and the problems addressed by professionals? According to Thomas S. Kuhn,

> "...textbooks do not describe the sorts of problems that the professional may be asked to solve and the variety of techniques available for their solution. Rather, these books exhibit concrete problem solutions that the profession has come to accept as paradigms, and they then ask the student, either with a pencil and paper or in the laboratory, to solve for himself problems very closely related in both method and substance to those which the textbook or the accompanying lecture has led him."[5]

Though Kuhn is speaking of science textbooks, his distinction between tutorial and professional problems is equally applicable in engineering. The distinction is confirmed, for example, by engineering educator Jay W. Forrester of MIT. According to Forrester:

> "[The engineer] must identify the significant and critical problems, but in his education, problems have been predetermined and assigned. He must develop the judgment to know what solutions to problems are possible, but in school the problems encountered are known to have answers. He should be excited by new and unsolved challenges, but for 20 years he has lived in an educational system where he knows he is repeating the work of last year's students."[6]

In short, both Kuhn and Forrester perceive a radical difference between tutorial and professional problems. A fuller contrast of the two types of problems is presented in the following table:

Table 1. Comparative Features of Tutorial and Professional Problems

	Tutorial Problems	Professional Problems
Origin	discipline-generated (autotelic)	organization-generated
Nature	pre-formulated, fully specified	ill-defined, ambiguous
	closed	open-ended
	general, abstract, formal	specific, concrete, practical
	"ideal"	"real"
Scope	context-impoverished, fragmented, atomistic	context-rich, holistic
Solutions	homogeneous, mathematically tractable,	heterogeneous
	pre-determined, unequivocal	provisional, multiple

Thus, on the one hand, the problem addressed by the student has been preformulated and fully specified; the single specific answer required is obtained using an analytical method which has just been introduced in the classroom. On the other hand, the problem addressed by the engineer is often ill-defined and is delineated along with various prospective solutions, only through diverse engineering activities. The engineer then chooses among these provisional solutions on the basis of comparative evaluation of projected cost and effectiveness; in effect, tradeoffs are made to realize the most cost-effective solution.

DISSOCIATION OF ACADEMIC AND PROFESSIONAL SPHERES

The enormous disparity between tutorial and professional problems is symptomatic of the long-standing dissociation of the academic and professional spheres of engineering. Surveying the history of engineering in the United States, Lawrence P. Grayson notes:

> "Almost from its beginning engineering education in the United States was in all essential aspects a form of collegiate education, instituted and directed by educators, rather than practitioners. It was firmly established before the profession organized itself, with curricula in the various branches of engineering being taught and degrees offered, before the corresponding professional societies were formed. As a result, engineering education did not evolve from apprenticeship training and only slowly replaced it, gaining the support of practitioners with considerable struggle... . These beginnings were directly opposite to the manner in which education for the legal, medical and dental professions developed in the United States, as they evolved out of apprenticeship on a purely practical and technical plane, with none of the general qualities of collegiate education."[7]

Grayson is speaking of the origins of engineering education for the older specializations, such as civil engineering, which though not professionally based was nonetheless technically rather than scientifically based. Engineering education for some younger specializations, such as electrical or chemical engineering, was originally scientifically rather than technically based, however, and the dissociation of "the professional" and "the academic" was even more pronounced. Admittedly, educations in the electrical and chemical specializations evolved from their scientific origins toward a technical base. However, this evolution was halted in the post-World War II and post-Sputnik eras which saw, in fact, an increasing commitment to the pure sciences in engineering curricula. The incursion of pure science into the curriculum occurred at the expense of the technical component; the professional component remained virtually absent.

In the modern era, science courses predominate in the first two years of engineering curricula; a strong scientific coloration persists into the last two years of undergraduate study. Moreover, these scientifically oriented curricula have increasingly been taught by a faculty with a science-oriented

education and little if any professional engineering experience. As the Goals Report of the ASEE notes: "Young men are entering faculty careers with doctoral degrees but with little if any experience in the practice of engineering."[8] The significance for students of having instructors with little or no professional engineering experience is summarized by Eric A. Walker: "There are engineers who graduate with little or no exposure to engineering because they have not studied with teachers who are engineers."[9]

What are the implications, for the professional communication instructor, of having engineering students trained in a discipline dissociated from a professional base at its very origins, enrolled in a science-oriented curriculum, and taught by instructors lacking professional experience? One implication seems clear: Rhetoric instructors should not consider engineering students experts in the articulation and treatment of problems addressed typically by professionals. In the remainder of this paper, we attempt to further substantiate this assertion largely on the basis of experience with a course in technical and professional communication. We discuss typical student difficulties in the selection and treatment of technical problems in simulated professional reports. Based on results obtained with questionnaires and in-depth interviews, these difficulties are traced to the use of tutorial materials as sources. Representative case histories are used to illustrate typical pitfalls in adapting tutorial source materials. We close with a few suggestions on the handling of the technical problem by rhetoric instructors.

THE COURSE; THE DIFFICULTY

We are involved in a senior-level, multi-sectioned course in technical and professional communication in the College of Engineering of the University of Michigan. The course objective is to train engineering students with a wide variety of specializations to write professional reports which are instrumentally useful for diverse audiences in organizations. Course assignments entail the generation of technical communications in which problem formulations are presented, and solutions advocated, for such audiences. The course is officially restricted to students who have had professional experience or who have taken, or are concurrently enrolled in, project or design courses; theoretically, such students should have no difficulty in fulfilling the assignments. In fact, however, most of our students have great difficulty in properly selecting, articulating and treating appropriate problems.[10] Why? In search of answers to this question, questionnaires and follow-up in-depth interviews were used over a two-year period among approximately 200 students. Two conclusions emerged: First, many students in the course do not meet the stated background requirements. Second, most students have major difficulties in adapting their selected source materials to meet the requirements of professional engineering reports. Specifically, their difficulties occur mainly because they attempt to adapt materials of an academic, or tutorial, nature. Lacking ready access to professional report materials, most students turn--somewhat understandably--to materials at hand, that is, to tutorial materials in their academic environment. Yet, as we have shown earlier, these materials usually differ profoundly from professional materials in both the nature and treatment of problems. Not surprisingly, then, the adaptation usually poses great difficulties.

CASE HISTORIES

Typical student difficulties are portrayed in the following case histories.

Case History 1. Lacking professional experience, Laura K. understandably turned to the most readily available materials--in this case, to a term paper written for a course dealing with integrated-circuit technology. She therefore wrote a report, ostensibly at her supervisor's request, summarizing the procedural steps for manufacturing integrated circuits in several different technologies. Like the term paper itself, the report showed the characteristic preoccupation of students with subject matter, and was largely pre-engineering in nature. Though the materials earned an "A" grade as a term paper, the report based on these materials was less successful. The response of an actual organization would surely have been: "How does this affect us?" or "Why should we know about this?" In fact, authorization of an organization report on so gratuitous a problem is unlikely. Rather, a report might have been requested in response to a question such as: Can changes in fabrication procedure increase productivity of our manufacturing division and produce profitability? This question in fact provided the basis for a later, and more successful, version of the report. However, lack of sufficient quantitative data became a serious difficulty when she attempted to address a specific organizational problem. Thus, though some deficiencies were remedied in the initial adaptation of the term paper, new ones arose when the treatment of a meaningful problem was undertaken: Clearly, she lacked such critical information as costs and yields under both the "old" procedure and the "new" procedure advocated in the report. Her solution, not infrequent in these cases, was to invent missing data in the interests of rhetorical effectiveness of the report--an exercise of highly dubious educational worth. Similar report scenarios are common among students who, lacking any sort of professional experience, turn for working materials to lecture notes, textbooks, or their counterparts in professional journals, i.e., the tutorial article. The difficulties of Laura K. are representative: They were, in fact, shared by Peter B. who wrote a report describing the architecture of a large-scale computer system based on lecture materials provided in a computer course; they were shared, equally, by David M. whose report discussed the general merits of high-voltage DC transmission based on a tutorial article in Spectrum, a journal of electrical *engineering*.

Case History 2. Unlike Laura K., Jeff R. began with meaningful organizational and technical problems: The construction company for which he "works" had seen a possible need, on the grounds of increased safety and marketability, for installing household fire-warning systems in homes under construction. Jeff's task was to assess the need and, if deemed appropriate, to specify the hardware to be installed. This is a very plausible engineering problem; however, the execution of the task, as described in his report, was largely ineffective. His basic difficulty was improper selectivity: He failed to raise critical issues, raised others which should not have been debated, and treated still others in insufficient detail. As a result, many of his decisions seemed, or were, arbitrary--and the report was unconvincing. For example, failure to recognize, generally, the relevance of building and

occupancy codes was a serious technical omission which ultimately impaired the rhetorical effectiveness of his report. In fact, the code requirements provided the one incontestable argument for installing household fire-warning systems. An organization might approve the recommendation that household fire-warning systems be installed on the grounds of humanitarian concern and possible enhanced marketability of the homes; it would certainly approve an installation which was a precondition for their sale. The failure to acknowledge requirements of operant codes led Jeff to consideration of issues which need not have been raised: For example, his fairly lengthy discussion of the merits of smoke-, as opposed to heat-, detectors was relatively persuasive, though somewhat beside the point, since the codes dictated the inclusion of smoke detectors. A more general characteristic of the report materials was a lack of sufficient detail. In consequence, his report recommended installing a system which seemed arbitrary in many respects: in the choices of ionization-, rather than photo-electric-, type smoke-detector units; of battery-powered, rather than line-powered, units; of five units to protect a three-bedroom home; of the placement of the units; and, indeed, of the specified model rather than, say, one of the competitive units available. Unfortunately, a lack of sufficient detail is easier to diagnose than to correct. In Jeff's case an extended effort would have been needed to access the information required to deal effectively with the issues involved. For example, a choice of a smoke-detector model for installation would certainly have entailed a comparative study of the specifications of a cross-section of commercially available units. The accummulation of a list of manufacturers, preparation of letters of inquiry, and wait for responses would have taken several weeks. When coupled with other demands of the problem, the total time and effort required for information accessing by a student becomes disproportionate in a course on technical communiation. But Jeff's pitfall, arbitrariness, is shared by many students: For example, improper treatment of cost factors is endemic in student reports.

The above case histories portray representative problems encountered by students who, though lacking professional experience, are nevertheless asked to stimulate an effective professional treatment of a meaningful technical problem. As we have seen, many of these problems can be traced to the nature of the typical sources used--textbooks, lecture notes, laboratory reports, tutorial articles.

SUGGESTIONS

Based on the foregoing analysis of student difficulties in articulating and treating technical problems, a number of suggestions can be made to help teachers of technical communications address more effectively the issues of professionalism. These suggestions range from general speculations on the nature and placement of professional communication courses in curricula to specific heuristics for evaluating the treatment of the technical problem by the student. What follows, then, is a series of suggestions with comments.

Suggestion 1: Consider introducing students to professional problems and the treatments demanded, in a communication course offered early in their academic programs.

Comment: We have found the case a promising method of confronting inexperienced students with a set of carefully metered demands to articulate, solve and report a "real-life" engineering problem within an organizational context.[11] A

case problem should be chosen which is "real", of general interest among engineering students, and of circumscribed difficulty.[12] The case materials provided students should probably be chosen with the cooperation of a member of the technical faculty.

Suggestion 2: Consider deferring a course in professional communication until late in the program, that is, until the senior year.
Comment: Such deferral, widely advocated in the literature,[13] has several advantages: First, more students will have had some sort of "professional" experience; certainly greater numbers of students will have taken either project or design courses--courses traditionally conceived as bridging the gap between "the academic" and "the professional." Second, regardless of the degree of exposure to professionalism, seniors will at least have more expertise with the technical subject matter of their engineering specializations. Third, seniors who are about to join the professional work force will understandably be more motivated to acquire the communication skills needed by professionals.

Suggestion 3: Whether you decide to introduce your students to professional communication early or late in their program, design your course to bridge the gap between "the academic" and "the professional" as that gap exists at your institution.
Comment: To do this, you need to consider both where your students are going to and where they are coming from. The nature and treatment of academic and professional problems have been characterized here in general terms. Beyond this, we endorse the oft-made suggestion that you learn more about the standards and conventions which your students will have to meet as professionals.[14] Equally as important, though relatively unnoted, is the need to understand in some detail the degree to which your students have been introduced to principles of professionalism in their course work. Clearly, answers to questions such as the following are helpful: For which engineering specializations, if any, is there a project- or design- course requirement at your school? In what numbers have your students availed themselves of opportunities for outside organizational experience through, for example, co-operative or summer programs? What pedagogical concessions need, and can, be made in the light of the backgrounds of students in an individual class?[15] In summary, profiles are needed for your engineering students in general, by specialization, and by individual class.

REPORT EVALUATION

Suggestion 4: In reading reports, assume responsibility for assessing the degree of professionalism manifested in the articulation and treatment of technical problems by students. As a corollary, don't let students relinquish responsibility for simulating treatment of appropriate problems at a professional level.
Comment: Do not assume the student is an expert in the articulation and treatment of problems addressed by professionals. Students may have mastery of technical subject matter, but not of professional problem treatment. Lacking such mastery, students attempt at times to persist in treating problems in imputing the academic, tutorial mode, e.g., by inputing to a supervisor the assignment of a task of sub-professional, or pre-professional, nature. Consider as suspect, then, any task assignments of the general form: "My boss asked me to [perform a sub-professional, or pre-professional, task]."

Suggestion 5: In examining reports, focus primarily at the level of underlying deep structure, or of disciplinary paradigms, rather than at the level of surface textualization.
Comment: To do this, you should be aware of the conventions underlying various discourse types in academic and professional writing. Armed only with a knowledge of the appropriate structural paradigm, the rhetoric teacher--however unfamiliar with the surface textualization of a given report, be it op amps or strain gages--can readily detect many serious flaws. Consider, for example, the structural paradigm for a problem-solving organizational report, which has the following elements: statements of the problem, methodology, results, conclusions, recommendations, and implications for the organization (i.e., cost, benefits, future actions required). A teacher familiar with this paradigm is able to question the omission of an element, such as recommendations, from a problem-solving organizational report. But both teacher and student can gain additional insight by comparing the paradigmatic elements of such an organizational report with their counterparts in the appropriate academic discourse genre--especially since, as we have shown, students tend to turn to such sources. Such a comparison is made in Table 2, using the student laboratory report as the academic discourse genre.

Table 2. Comparison of the structural paradigms for a student laboratory report and a professional problem-solving organizational report.

	Student Lab. Report	Professional Report
Technical Problem	tutorial	professional
Methodology	highlighted	de-emphasized, if standard
Results	emphasized	details appended
Conclusions	emphasized, but narrow	emphasized
Recommendations	omitted	emphasized
Implications	omitted	emphasized

In the case under discussion, recommendations may well have been omitted because they are not ordinarily called for in a student laboratory report. Figure 2 illustrates, then, one example of the level at which you should be not only reading reports but also characterizing discourse types for your students. It is implicit in the above discussion that we do not advocate an attempt to master the subject matter of, say, an electronic circuit text or a dynamometer user manual.[16] However, we do advocate familiarization with the structural paradigms underlying discourse sub-genres such as textbooks and user manuals.

Suggestion 6: Be aware that the norms underlying various engineering paradigms evolve, and try to keep up with changing conventions.
Comment: An example might be helpful here. The traditional professional design paradigm includes the following elements: function, cost, manufacturability, and marketability. Note, however, that traditional design education is focused largely on function. Following the method of Suggestion 5--detection of possible student errors through a comparison of academic and professional paradigms--we are led to expect, and indeed find, imbalances in student treatments of the four elements of the professional design paradigm. But more relevant to our present point, this paradigm is evolving. Specifically, the addition of

safety to the traditional design paradigm is increasingly regarded as mandatory.[17] Moreover, because this design criterion is just beginning to be recognized in engineering education, one expects its omission to be the exception rather than the rule in student writing. Trends such as energy and resource conservation, and environment protection, are inducing further evolution of the professional design paradigm.

Suggestion 7: Don't accept arbitrariness--a characteristic of treatment of formal, tutorial problems--at any level of a professional report.
Comment: In an earlier discussion we noted that while tutorial problems are abstract, idealized and general, professional problems are concrete, "real", and specific. Thus, while a circuit may "operate at 300°K" in a textbook discussion, qualification is required in a professional description. The qualifications required in professional treatments of a problem often take the form of ranges. In the example cited above, specification of an operating temperature range would be required, e.g., 300± 2°K. Similarly, the provisional, multiple nature of solutions to professional problems should lead you to challenge any solution deemed, in effect, unique. Remember that you need not have the specific answers to ask the right questions.

CONCLUSION

In the above suggestions, and in the paper as a whole, we have tended to treat engineering in the broad sense as normatively conceived. But, as we noted in the case of evolving design criteria, norms change and the conventions for the engineering profession are neither monolithic nor static. Nor are they ever fully realized in any given instance: The claim has been made, for example, that many of today's engineers are working at sub-professional levels.[18] How does the rhetoric instructor accommodate the statistically significant group of students who may have this destiny? Or to treat the other side of the coin, in effect, a certain number of educators--including ourselves--are calling for a new engineering professionalism.[19] Jay Forrester calls, for example, for a renaissance figure who "should act as the interface between technology, economics, organization, and politics."[20] What, if any, should be the rhetoric instructor's role in producing this new engineer? Whatever choice is made, pedagogical decisions have moral implications. And those decisions should be conscious and responsible.

FOOTNOTES

1. See, for example, Fred H. MacIntosh, "Teaching Writing is the World's Work," The Teaching of Technical Writing, eds. Donald H. Cunningham and Herman A. Estrin (Urbana: NCTE, 1975), p. 29: "But make clear to your students that content is their responsibility, and that your concern is clarity of presentation..." The historical emphasis on style and arrangement is confirmed and related to the tradition of scientific positivism by Carolyn R. Miller in "A Humanistic Rationale for Technical Writing" College English, vol. 40, no. 6, Feb. 1979, pp. 610-17.

2. For a notable exception, see the pioneering treatment of the technical problem in J.C. Mathes and D.W. Stevenson, Designing Technical Reports: Writing for Audiences in Organizations (Indianapolis: Bobbs-Merrill, 1976), especially Chapter 3.

3. Moreover, we are told that students "enjoy the opportunity to teach their teachers." Paul V. Anderson, "Teaching the Teacher What Government and Industry Want from Technical Writing," Technical and Professional Communication: Teaching in the Two-Year College, Four-Year College, Professional School, ed. T.M. Sawyer (Ann Arbor: Professional Communication Press, Inc., 1977), p. 66.

4. Marion K. Smith, "What Should be Taught in the Technical Writing Course?" in Technical and Professional Communication, pp. 46-47.

5. Thomas S. Kuhn, "The Essential Tension: Tradition and Innovation in Scientific Research," The Essential Tension: Selected Studies in Scientific Tradition and Change (Chicago: University of Chicago Press, 1977), p. 229.

6. From a speech entitled "Engineering Education and Engineering Practice in the Year 2000" and delivered during the National Academy of Engineering session of the Engineering Sesquicentenial Celebration at the University of Michigan on September 21, 1967.

7. "A Brief History of Engineering Education in the United States," Engineering Education, Dec. 1977, p. 246.

8. Cited in Eric A. Walker, "Teaching Research Isn't Teaching Engineering," Engineering Education, Jan. 1978, p. 306.

9. Ibid.

10. For the occasional student with professional experience and professional report materials available, fulfilling course assignments poses no great difficulty. This individual need only select from personal files a report which can be adapted, if necessary, for purposes of the course.

11. For a discussion of our experiences with the case method, see Ben F. Barton and Marthalee S. Barton, "Bridging the Gap Between Engineering Student

and Professional: The Case Method in a Technical Communication Course," Courses, Components, and Exercises in Technical Communication, ed. Dwight W. Stevenson (Urbana: NCTE, 1981).

12. These three criteria underlay our choice of a case problem. That is, we sought first a "real" problem representative of those actually encountered in practice by entry-level engineers. Second, we wanted a problem which could be handled without a deep understanding of concepts peculiar to any one engineering specialization, a problem which would permit a focus on the structural paradigm underlying all engineering specializations, i.e., the problem-solving methodology. Third, we desired a problem which could be treated adequately in a one-term technical-communication course.

13. See, for example, J.C. Mathes, Dwight W. Stevenson, and Peter Klaver, "Technical Writing: The Engineering Educator's Responsibility," Engineering Education, Jan. 1979, pp. 331-34; W.E. Britton, "The Trouble with Technical Writing is Freshman English," Journal of Technical Writing and Communication, Spring 1974, pp. 127-31; T.M. Sawyer, "First Things Last: Composition for Seniors, not Freshmen," Journal of Technical Writing and Communication, April 1971, pp. 139-46.

14. Paul Anderson ("Teaching the Teacher," p. 65) goes so far as to suggest that "[t]eachers of technical writing are not fully trained until they have worked as writing specialists in business, government, industry or wherever they expect their students to be employed after graduation."

15. For example, it was recently possible in a section which happened to have 10 students from a single chemical-engineering design course, to encourage team report-writing--an important aspect of professional activity.

16. Our position differs, then, from that implied by advice such as the following: "Your first logical question may be: how can I teach students to write about things of which I know very little? The first obvious answer is: Read the texts, materials, manuals, and instruction sheets your students use in their career courses. Most of these materials are simple and lend themselves to fast reading for general information. Make clear to your students that context is their responsibility and that your concern is clarity of presentation..." Fred H. MacIntosh, "Teaching Writing is the World's Work," p. 29.

17. See, for example, Tim A. Jur et al., "Engineering, the Law, and Design Education," Engineering Education, Jan. 1981, p. 274: "The elimination of unreasonable [sic] risks of inquiry has become a significant design constraint and must not be overlooked in the design education process." Also, J.M. Christensen, "Implications of Product Liability for Engineering Design and Education," Engineering Education, Dec.1977, pp. 274-77.

18. William S. Byers, "Should Engineering Graduates Be Allowed to Become Technologists?", Engineering Education, May 1977, p. 761: "It is probable, by ECPD's definitions, that a majority of engineers in industry

are performing as technologists." See also Clarence W. de Silva, "The Computer: Obstacle to a Meaningful Engineering Education," Engineering Education, Jan. 1981, p. 304: "On the other hand, there are industries that often use qualified engineers as computer users rather than as productive engineering problem solvers."

19. Ben F. Barton and Marthalee S. Barton, "Toward Teaching a New Engineering Professionalism: A Joint Instructional Effort in Technical Design and Communication," in Technical and Professional Communication, pp. 119-28.

20. "Engineering Education and Engineering Practice in the Year 2000."